

# Getting Started with MUSCAT API & Portal Requests

Author: Jon Nation & Daniel Harbeck

Last revision: Sept 15 2023

This document provides an introduction to the MuSCAT settings for users who intend to submit observation requests via the LCO Portal or the API. **Familiarity with the LCO Web-Portal and API submission process is assumed.**

## Notice of change September 2023:

The API definition for optical elements changes as of September 2023 to reflect the transition from photonic diffusers in MuSCAT3 to narrow-band filters in MuSCAT4 / MuSCAT3. Photonic diffusers at MuSCAT3 will be unavailable. Confer with the MuSCAT4 release notes for more details.

Observing API requests that contain the former optical element definition for the diffuser (e.g., 'optical\_elements': {'diffuser\_g\_position': 'out',}) will be automatically converted to narrowband\_\*\_position:out, i.e, broad band imaging.

## Table of contents:

[Overview](#)

[Portal submission](#)

[API submission](#)

[Exposure Type](#)

[Exposure Times](#)

[Exposure Mode](#)

[Readout Modes](#)

[Narrow-band Filter States](#)

[Finer points](#)

[Use of exposure mode and configuration type](#)

[Note on auto-guiding](#)

## Overview

The MUSCAT instrument consists of four separate cameras in the g', r', i', and zs bands capturing images of the same field of view. For MuSCAT, each of the four passbands is referred to as a 'channel'. [Refer to the LCO Muscat web page for more background information on the instrument design.](#) This guide describes the new configuration items for the MUSCAT instrument. Background material on API submission can be found on the [developers page](#) or in the [observation portal API submission examples](#).

As for all LCO observing requests, the following parameters have to be defined:

- An *Exposure Type*, which defines for repeated exposures if the number of repeats is driven by the number of exposures, or a time duration to fill. In the first case, a number of repeats is to be defined; in the latter case, a duration will need to be defined.





A Muscat observation request in particular must define the following parameters:

- An *Exposure Time* for each of the four channels.
- An *Exposure Mode*, which defines how repeated exposures are executed in different channels.
- A *Readout Mode*, which defines the readout speed of the camera's CCDs.
- A *narrow-band filter position*, which defines, for each channel, whether a narrow-band filter is to be inserted into the beam in lieu of the the broad band filter.

## Portal submission

The following screenshots exemplify a portal submission form for a Muscat request. Refer to the explanation of the API requests later in this document for detailed discussion of the meaning of each parameter.

The Portal example #1 and API example #1 represent an identical request for 100 synchronously repeated observations with exposure times of 27s, 33s, 23s, and 30s in the g',r',i', and z' channels, respectively. The narrow-band filter optical elements are out of the beam for all channels.



**Configuration**



- [More information about LCO instruments.](#)
- For more information on the different options, see the "Getting Started" guide in our [Documentation section](#).
- Dithered observations should be specified either by setting pattern parameters here or by manually setting Right ascension and Declination Offsets within the Instrumentation Configuration section.





Observation Type

Instrument

Guiding ?  ☒ Optional

Type ?

Dither ?



**Instrument Configuration**



- Try the [online Exposure Time Calculator](#).

Exposure Count

Exposure Mode ?

Exposure Time g ?

Exposure Time r ?

Exposure Time i ?

Exposure Time z ?

Readout Mode

Narrowband r position

Narrowband i position

Narrowband g position

Narrowband z position

Defocus ?

Offset Right Ascension ?





Offset Declination ?

*Muscat portal submission example #1*

The Portal example #2 and API example #2 represent an identical request for asynchronous exposures with exposure times of 27s, 33s, 23s, and 30s in the g',r',i', and zs channels, respectively, that are to continue for 4 hours. The narrow-band filters are to be in the beam.<sup>1</sup>

---

<sup>1</sup> Note: In this revision, the screen shot of the portal request does not contain the Readout mode field.



**Configuration**



- [More information about LCO instruments.](#)
- For more information on the different options, see the "Getting Started" guide in our [Documentation section](#).
- Dithered observations should be specified either by setting pattern parameters here or by manually setting Right ascension and Declination Offsets within the Instrumentation Configuration section.

Observation Type





Instrument

Guiding?  ☒ Optional

Type?

Duration?

Dither?



**Instrument Configuration**



- Try the [online Exposure Time Calculator](#).

Exposure Count

Exposure Mode?

Exposure Time g?

Exposure Time r?

Exposure Time i?

Exposure Time z?

Readout Mode

Narrowband r position

Narrowband i position

Narrowband g position

Narrowband z position

Defocus?

Offset Right Ascension?

Offset Declination?

*Muscat portal submission example #2*

## API submission

The following two excerpts illustrate the Muscat specific JSON configuration for an API request submission. They represent the same requests as in the Portal submission section of this document. Note that the human-readable representation in the Portal and the notation in the API might slightly differ.

```
'configurations': [{
  'type': 'EXPOSE',
  'instrument_type': '2M0-SCICAM-MUSCAT',
  'guiding_config': {},
  'instrument_configs': [{
    'exposure_time': 33.0,
    'exposure_count': 100,
    'mode': 'MUSCAT_FAST',
    'optical_elements': {
      'narrowband_g_position': 'out',
      'narrowband_r_position': 'out',
      'narrowband_i_position': 'out',
      'narrowband_z_position': 'out',
    },
    'extra_params': {
      'exposure_time_g': 27.0,
      'exposure_time_r': 33.0,
      'exposure_time_i': 23.0,
      'exposure_time_z': 30.0,
      'exposure_mode': 'SYNCHRONOUS'
    }
  }], ...]
}, ...]
```

*Muscat API submission example #1*

```

'configurations': [{
  'type': 'REPEAT_EXPOSE',
  'repeat_duration': '14400',
  'instrument_type': '2M0-SCICAM-MUSCAT',
  'guiding_config': {},
  'instrument_configs': [{
    'exposure_time': 33.0,
    'exposure_count': 1,
    'mode': 'MUSCAT_FAST',
    'optical_elements': {
      'narrowband_g_position': 'in',
      'narrowband_r_position': 'in',
      'narrowband_i_position': 'in',
      'narrowband_z_position': 'in',
    },
    'extra_params': {
      'exposure_time_g': 27.0,
      'exposure_time_r': 33.0,
      'exposure_time_i': 23.0,
      'exposure_time_z': 30.0,
      'exposure_mode': 'ASYNCHRONOUS'
    }
  }, ...]
}, ...]

```

*Muscat API submission example #2*

The meaning of the individual requests are discussed in the following:

## Exposure Type

Repeated exposures can be defined for LCO instruments in two ways, the the **type** keyword has to set according to the desired mode; for a single exposure, set the type keyword to 'EXPOSE'.

1. Take a defined number of repeated exposures. In this case, set the **type** keyword to 'EXPOSE', and set the **exposure\_count** keyword in the instrument config to the number of

requested exposures.

2. Fill a certain duration with as many exposures of the defined exposure time as can fit. In this case, you would set the **type** keyword at the configuration level to be **REPEAT\_EXPOSE** instead of **EXPOSE**, and then set a **repeat\_duration** keyword at the configuration level to be the total observation time in seconds you want to repeat that set of **instrument\_configs** for. It is recommended to set the **exposure\_count** keyword to 1.

## Exposure Times

Each camera is operated independently. An exposure time must be specified for each channel; the exposure times do not have to be identical, but can be. Customizable exposure times allow the sensitivity of each channel to be matched to the spectral energy distribution of a science target.

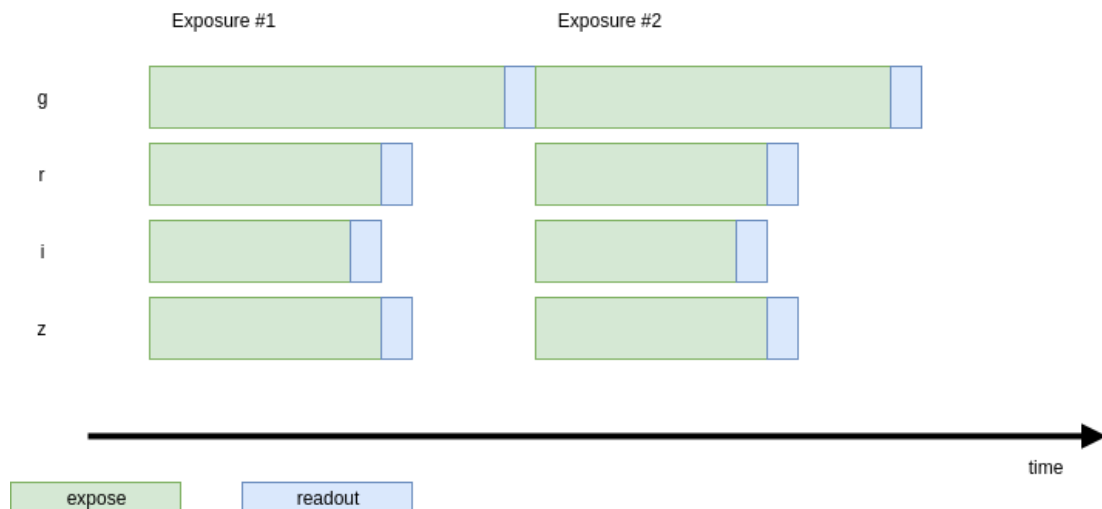
In the API, the four exposure times are specified in seconds by the **exposure\_time\_\*** keywords in the **extra\_params** section of the **instrument\_configs** dictionary. (The \* is a placeholder for the filter: g, r, i, z.) The base **exposure\_time** at the **instrument\_configs** level indicates the longest of the four exposure times. When the request is submitted, the **exposure\_time** will be overwritten with the longest **exposure\_time\_\*** value, if the values differ; the user does not have to define this keyword, but might want to be aware that it will be generated by the API interface for bookkeeping. The duration of the request is based on the longest **exposure\_time\_\***, as well.

**Note:** The **exposure\_time** field must be either filled with a dummy time, or not be part of the json structure. A request with the **exposure\_time** field set to None or null will be rejected.

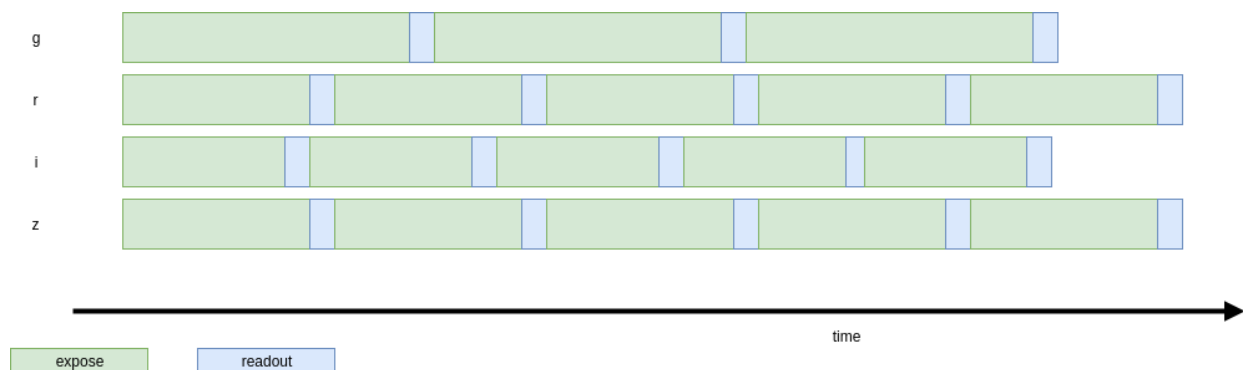
## Exposure Mode

MuSCAT can operate in either a synchronous or an asynchronous exposure mode. In synchronous mode (Figure 1), all channels complete an exposure before the next set of exposures start. In asynchronous mode (Figure 2), each channel acquires exposures as fast as it can.





**Figure 1:** SYNCHRONOUS mode. The start time of each set of 4 exposures is synchronized, so the cadence will be determined by the longest exposure time among the 4 cameras (plus readout time).



**Figure 2:** ASYNCHRONOUS mode. The exposures for the 4 cameras happen independently and as quickly as possible.

The exposing mode is specified in the API by setting the `exposure_mode` keyword in the `extra_params` section to either **SYNCHRONOUS** or **ASYNCHRONOUS**. The default setting is **SYNCHRONOUS**.

## Readout Modes

The Muscat cameras can be read out at two speeds, MUSCAT\_FAST and MUSCAT\_SLOW. The different readout modes offer different trade-offs between speed and read noise; refer to the MuSCAT3 documentation for details. The readout mode is defined via the `mode` keyword in the `instrument_config` group. If `ninstrument_config` is not defined it will default to MUSCAT\_FAST.

## Narrow-band Filter States

The MUSCAT instrument has a narrow-band filter option for each of its cameras to enable photometry of bright stars that would otherwise saturate, or, in the  $r'$ -band, a filter centered on the Sodium D line. The narrow band filter mechanism knows the two states of **in** or **out**. By default, the narrow-band filters are **out** of the optical path. It can be moved **in** to the optical path in lieu of the broad band filter. The narrow-band filter states can be set in the API the same way filters are, using the `narrowband_*_position` key in the `optical_elements`, where the `*` denotes the channel for which the narrow-band filter should be inserted [g, r, i, z].

**MuSCAT3 in the northern hemisphere, until upgraded to narrow band filters later in 2023, will only schedule observations with the narrowband\_\*\_position set to OUT.**

# Finer points

## Use of **exposure\_mode** and configuration **type**

The combination of **exposure\_mode** and configuration **type** control the behaviour of repeated exposures. The typical use cases for the combinations are outlined in the following:

- Type: EXPOSE, exposure\_mode: SYNCHRONOUS  
Default multi-color photometry with a single or multiple exposures for cosmic ray rejection (e.g., Supernova follow up, pretty picture)
- Type: REPEAT\_EXPOSE, exposure\_mode: ASYNCHRONOUS  
Planet transit with optimum signal-to-noise per channel.
- Type: REPEAT\_EXPOSE, exposure\_mode: SYNCHRONOUS  
Fast cadence light curve where synchronous exposing is important, e.g. asteroid rotation curves.
- Type: EXPOSE, exposure\_mode: ASYNCHRONOUS  
*No specific use case has been identified yet; listed for completeness.*

## Note on auto-guiding

Muscat observations can be guided by using either the facility guider or Muscat images themselves. See MuSCAT3 Release Notes for details and trade-offs. The guide behaviour can be controlled in the portal via a guide mode selection, or in the API by configuring the `guide_config` in a request configuration.

To guide with the facility guider:

```
'guiding_config': {'mode': 'ON'}
```

To self-guide with Muscat:



```
'guiding_config': {'mode': 'OFF'}
```

If the `guide_config` field is undefined, API calls will default to will default to



```
'guiding_config': {'mode': 'ON'}
```

i.e., to the use of the facility guider.

In the web portal the guide mode will be selected in the Configuration->Guiding section:

Configuration

- For more information on the different options, see the "Getting Started" guide in our [Documentation section](#).

Guiding ?

Optional

⌵

Type ?

Exposure

⌵

- Select the facility guider by choosing "Optional" - We show this in the portal as Optional rather than ON because even if there were no guide stars found in the facility guider, the Muscat observation request would still continue, but unguided.

Guiding ? Optional ⌵

- Select Musat self-guiding by choosing the OFF option:

Guiding ? Guide Off ⌵